Chapter B1: Background

This case study presents the results of an analysis performed by EPA to assess the potential benefits of reducing the cumulative impacts of impingement and entrainment (I&E) at cooling water intake structures (CWIS) within the transition zone of the Delaware Estuary that are in scope of the proposed § 316(b) Phase II (existing facilities) regulation. In-scope facilities include any steam electric power generating facility that (1) is a point source that uses or proposes to use a cooling water intake structure, (2) has a design intake flow equal to or greater than 50 MGD, and (3) withdraws water from waters of the United States or obtains cooling water by any sort of contract or arrangement with an independent supplier (or suppliers) that withdraws water from waters of the United States.

CHAPTER CONTENTS

EPA chose the transition zone of the estuary for a study of cumulative CWIS impacts because of its ecological, economic, and recreational importance and its susceptibility to harm from multiple CWIS. The Agency is limiting its analysis of the Delaware Estuary to the transition zone because the facilities within this zone impinge and entrain the same species. Section B1-1 of this chapter provides information on both in-scope and out-of-scope CWIS within the transition zone, Section B1-2 describes the aquatic environment of the case study area, Section B1-3 discusses cooling water use by transition zone CWIS, and Section B1-4 presents information on the region's social and economic characteristics.

B1-1 Overview of Transition Zone Case Study Facilities

Figure B1-1 indicates the locations of all in-scope and out-of-scope CWIS throughout the Delaware River Basin. Those in green are in scope of Phase II of the § 316(b) regulation. This case study focuses only on CWIS within the transition zone of the Delaware Estuary, including four in scope power plants (Salem Nuclear Generating Station, Hope Creek Nuclear Generating Station, Edge Moor Power Plant, and Deepwater Generating Station), three out-of-scope power plants (Hay Road, Logan Generating Company, and Chambers Cogen LP), and six out-of-scope manufacturing facilities (Delaware City Refinery, E.I. DuPont de Nemours and Company Chemicals and Pigments Department, General Chemical Corporation, SPI Polyols, Citisteel, and Sun Refining). The locations of these facilities are indicated in Figure B1-2. The in scope power plants of the transition zone are described briefly below, and Table B1-1 summarizes their technical characteristics.

Figure B1-1: The Delaware River Basin

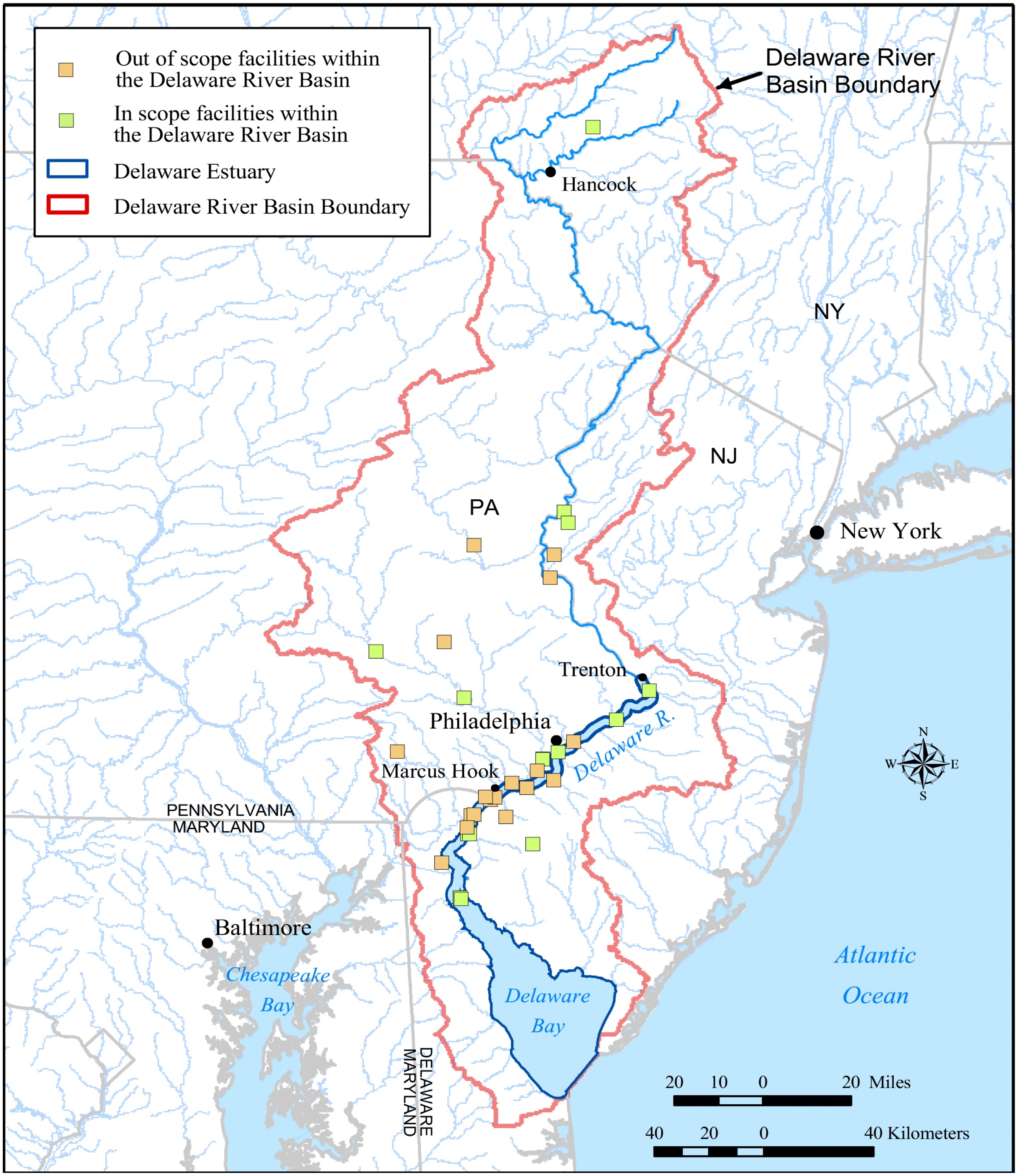

Figure B1-2: The Delaware Estuary and the Case Study Facilities of the Transition Zone

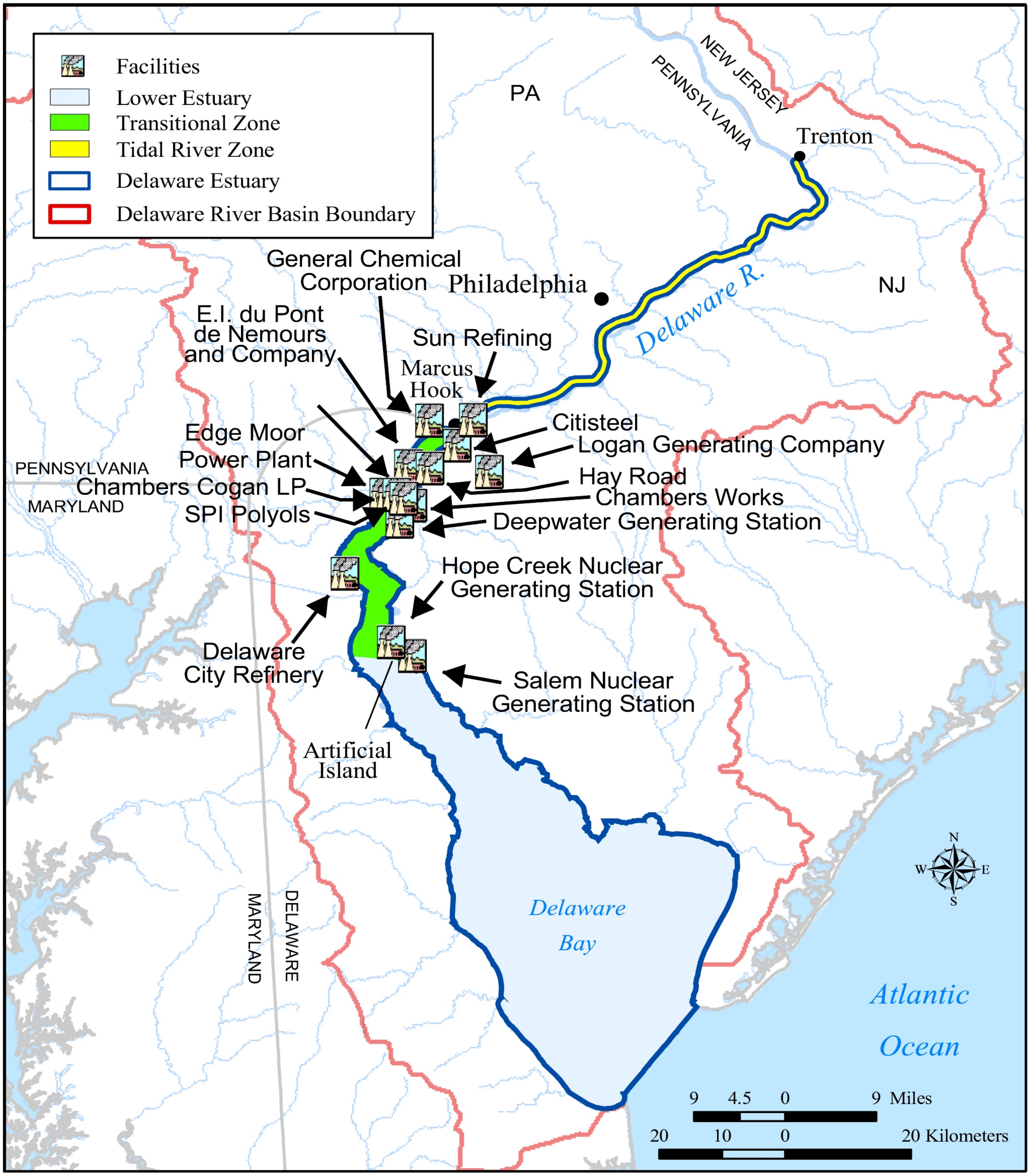

Table B1-1: Summary of Delaware Estuary Power Plants (1999)

	Salem	Hope Creek	Edge Moor	Deepwater
Plant EIA Code	2410	6118	593	2384
NERC Region	MAAC	MAAC	MAAC	MAAC
Total Capacity (MW)	2,382	1,170	710	259
Primary Fuel	Uranium	Uranium	Oil/Coal	Coal/Gas
Number of Employees	425	399	119	48
Net Generation (million MWh)	15.9	7.7	2.2	0.38
Estimated Revenues (million)	$1,373	$663	$141	$43
Total Production Expense (million)	$358	$174	$76	$18
Production Expense (¢/kWh)	2.256¢	2.268¢	3.405¢	4.908¢
Estimated Operating Income (million)	$1,015	$489	$65	$25

Notes: NERC = North American Electric Reliability Council
MAAC = Mid-Atlantic Area Council
Dollars are in $2001.
Source: Form EIA-860A (NERC Region, Total Capacity, Primary Fuel); FERC Form-1 (Number of Employees, Net Generation, Total Production Expense).

The **Salem Nuclear Generating Station** (Salem) is located on the Delaware Estuary in New Jersey, on an artificial peninsula known as Artificial Island. Artificial Island is the dividing line between the transitional and lower estuary. This section of the estuary is approximately 4 km (2.5 miles) wide, and is situated in the transition zone of the estuary. Tidal flow in this area is approximately 11,327 m^3/s (400,000 cfs; NJDEP, 2000). Salem operates two large nuclear units of 1,170 MW each.[1] Both units serve baseload demand. Unit 1 began operation in 1977, and is licensed to operate through June 30, 2017. Unit 2 began operation in 1981, and is licensed to operate through October 13, 2021. Each unit has a once-through cooling system with a design flow of 1,584 MGD. Estuary water is drawn in approximately 122 m (400 ft) north of the circulating water system, where it cools heat exchangers and other equipment before it is discharged back into the estuary (Correia et al., 1993). In addition to the two nuclear units, Salem operates one gas-fired generating unit, which does not require cooling water.

In 1999, Salem had 425 employees and generated 15.9 million MWh of electricity.[2] Estimated 1999 revenues for the Salem plant were approximately $1.4 billion, based on the plant's 1999 estimated electricity sales[3] of 14.7 million MWh and the 1999 company-level electricity revenues of $93.14 per MWh. Salem's 1999 production expenses totaled $358 million, or 2.256¢ per kWh, for an operating income of $1,015 million.

The **Hope Creek Nuclear Generating Station** (Hope Creek) is less than half a mile northwest of the Salem Nuclear Generating Station, and thus has the same estuary characteristics as the Salem facility. Commercial operation at Hope Creek began in 1986. The facility has one boiling water nuclear reactor capable of generating 1,170 MW. Like Salem's units, the Hope Creek reactor is operated as a baseload unit.

Salem and Hope Creek Ownership Information

Salem and Hope Creek both began operation as regulated utility plants and are both currently owned by PSEG Power. Salem and Hope Creek were purchased by PSEG Power from Public Service Electric & Gas Company (PSE&G), a regulated utility company, in August 2000.

PSEG Power is a wholly owned, nonregulated subsidiary of Public Service Enterprise Group (PSEG) Incorporated. PSEG Power was established in 1999 to purchase and operate the nonregulated generation assets of PSEG (Standard & Poor's, 2001a). PSEG Power is a domestic, competitive energy company with 3,100 employees. PSEG Power owns or controls more than 11,200 MW of electric generating capacity and intends to add an additional 6,100 MW. In 2000, PSEG Power posted revenues of $1.0 billion (PSEG, 2001a,d,e).

[1] The data on electric generating units in this chapter come from the 1999 Forms EIA-860A (U.S. Department of Energy 2001b) (Annual Electric Generator Report – Utility) and 860B (U.S. Department of Energy 2001c) (Annual Electric Generator Report – Nonutility).

[2] One MWh equals 1,000 kWh.

[3] Electricity sales are net generation adjusted for utility-specific energy losses, energy furnished without charge, and energy used by the utility's own electricity department. See *Chapter C2: Cost Impact Analysis* for details on the estimation of plant-level electricity sales.

The design flow for the facility is 115.2 MGD. The Hope Creek facility uses a closed-cycle circulating water system consisting of four circulating water pumps. The system holds 9 million gallons of water (PSEG, 1989).

In 1999, Hope Creek had 399 employees and generated 7.7 million MWh of electricity. Estimated 1999 revenues for the Hope Creek plant were approximately $663 million, based on the plant's 1999 estimated electricity sales of 7.1 million MWh and the 1999 company-level electricity revenues of $93.14 per MWh. Hope Creek's 1999 production expenses totaled $174 million, or 2.268¢ per kWh, for an operating income of $489 million.

The **Edge Moor Power Plant** is located at rivermile 72.3 of the Delaware Estuary, just upstream of Wilmington, Delaware. The facility began commercial service in 1951. Edge Moor currently has four active generating units: units 3 and 4 are coal-steam units of 75 and 177 MW, respectively; unit 5 is an oil-steam unit of 446 MW, and unit 10 is a small gas turbine. Edge Moor's units are located in three separate pumphouses. Pumphouse 1 houses units 1 and 2, and contains two traveling screens for each unit; both units retired in 1983. Pumphouse 2 houses units 3 and 4, and contains three traveling screens for unit 3 and two for unit 4. Pumphouse 3 houses unit 5, and contains eight traveling screens. Each unit has one circulating pump operating full time. The average intake flow at unit 5 is reported as 558 MGD, and units 3 and 4 have an average intake flow of 224.5 MGD. The approach velocity as water passes through the traveling screens at the intake structures is 0.5 to 0.85 fps. Organisms impinged on the traveling screens are washed off into a trough and returned to the Delaware River when the screens are rotated (Versar, 1990).

Edge Moor and Deepwater Ownership Information

Edge Moor and Deepwater both began operation as regulated utility plants and are both currently owned by Conectiv. Conectiv purchased Edge Moor from Delmarva Power & Light Company in July 2000. Conectiv merged with Atlantic Energy Inc. (previously the owner of Atlantic City Electric Company) in March 1998 and assumed ownership of Deepwater.

Conectiv Corporation is a domestic, competitive energy company with 3,800 employees (Hoover's Online, 2001d). Conectiv owns or controls more than 4,000 MW of electric generating capacity (Conectiv, 2001). In 2000, Conectiv posted revenues of $5.0 billion (Hoover's Online, 2001d). During the first quarter of 2002, Conectiv is anticipated to merge with Potomac Electric Power Company (Pepco) in a $2.2 billion transaction that will create a single holding company which will serve more than 1.8 million customers in the mid-Atlantic region (PR Newswire, 2001).

In 1999, Edge Moor had 119 employees and generated 2.24 million MWh of electricity. Estimated 1999 revenues were approximately $141 million, based on the plant's 1999 estimated electricity sales of 2.16 million MWh and the 1999 company-level electricity revenues of $65.20 per MWh. Edge Moor's 1999 production expenses totaled $76 million, or 3.405¢ per kWh, for an operating income of $65 million.

The **Deepwater Generating Station** is located on the east side of the Delaware River in New Jersey, just north of the Delaware Memorial Bridge. The facility began commercial service in 1930. Deepwater currently has three steam electric units: unit 1 is a natural gas unit of 96 MW, unit 4 is an oil unit of 53 MW, and unit 6 is a coal unit of 92 MW. Each unit has a separate cooling water intake. All three intakes are located approximately 32 m (105 ft) offshore in the Delaware River (U.S. Department of Energy, 2001a). In the 2000 EPA questionnaire, the Deepwater Generating Station reported the design intake flow for units 1, 4, and 6 at 151 MGD; the average intake flow for these same units was 104.6 MGD. In addition to the steam electric unit, Deepwater operates one gas turbine which does not require cooling water.

In 1999, Deepwater had 48 employees and generated approximately 376,000 MWh of electricity. Estimated 1999 revenues were approximately $43 million, based on the plant's 1999 estimated electricity sales of 351,000 MWh and the 1999 company-level electricity revenues of $122.74 per MWh. Deepwater's 1999 production expenses totaled over $18 million, or 4.908¢ per kWh, for an operating income of $25 million.

B1-2 Environmental Setting

B1-2.1 The Delaware Estuary

The Delaware River Basin (Figure B1-1) encompasses some 35,066 km^2 (13,539 m^2), including parts of Pennsylvania, New Jersey, New York, and Delaware (DRBC, 2001). The main stem of the Delaware River is fed by 216 tributaries along its 531 km (330-mile) course from Hancock, New York, to the mouth of the Delaware Bay. Nearly three-quarters of the nontidal portion of the river is now included in the National Wild and Scenic Rivers Program (DRBC, 2001).

The Delaware Estuary is the tidally influenced portion of the Delaware River Basin, and is one of the largest estuaries of the U.S. Atlantic Coast (Santoro, 1998; DRBC, 2001). It extends 214 km (133 miles), from the falls at Trenton, New Jersey, to the mouth of Delaware Bay, and includes some 1,878 km^2 (725 mi^2) of open water. The C&D Canal at rivermile 59 provides a sea-level connection between the estuary and the upper Chesapeake Bay. A substantial exchange of water occurs through the canal, with average net flow from the Chesapeake Bay to the Delaware Estuary.

The annual mean freshwater inflow to the Delaware Estuary is about 574 m^3 (20,243 cfs), most of which is provided by the nontidal Delaware and Schuylkill rivers (PSEG, 1999c). Highest flows are in March and April and lowest flows are in August and September. Although there is a longitudinal change in salinity from 30 ppt at the mouth of the estuary to freshwater at Trenton, New Jersey, vigorous mixing results in little variation in salinity with depth (PSEG, 1999c). When freshwater inflow is low, higher salinity water moves up-estuary, and when freshwater inflow is high, saline waters move down-estuary.

For most of its length, the estuary is a broad, shallow body of water, with an average depth of 5.8 m (19 ft) and maximum depth of 45.1 m (148 ft). It is divided into three ecological zones based on salinity, turbidity, and biological productivity (PSEG, 1999c):

- The first section is the tidal river zone and consists of an 86.9 km (54 miles) long, heavily urbanized, tidal freshwater area of 64.7 km^2 (25 mi^2). This zone extends from Trenton, New Jersey, to Marcus Hook, Pennsylvania, just north of the Pennsylvania-Delaware state line**.** It is profoundly affected by urban, commercial, and industrial activities along its shores. It carries high nutrient levels from municipal discharges and also receives significant inputs of dissolved metals and organic pollutants.

- The second section is the transition zone and runs from Marcus Hook, Pennsylvania, to Artificial Island, New Jersey. The transition zone is the focus of this case study. It has a wide salinity range (from 0 to 15 ppt, depending on river flow and tidal currents), high levels of turbidity **and lower levels of biological productivity and diversity than the lower estuary. The transition zone is** brackish and influenced by salt water from the bay. It is also an area with a significant amount of sedimentation. Because of its brackish nature, it is the least biologically productive of the three zones. However, extensive shallow mudflats, sandbars, and tidal marshes in the nearshore areas of the transition zone provide important feeding and nursery areas for hundreds of fish, invertebrates, and bird species.

- The third section is the lower estuary, which is Delaware Bay itself, extending from the mouth of the bay to Artificial Island. It has the highest salinity levels, ranging from less than 5 ppt to more than 30 ppt depending on flow conditions, and is responsible for over 90 percent of the biological productivity of the entire estuary.

The map of the Delaware Estuary in Figure B1-2 shows the locations of these three ecological zones of the estuary and the locations of the CWIS within the transition zone that are evaluated in this case study.

B1-2.2 Aquatic Habitat and Biota

The major habitats of the Delaware Estuary include the open water (pelagic) zone, littoral zone, benthic zone, and tidal marsh zone (PSEG, 1999c; U.S. EPA/ORD, 1998). These habitats support a wide range of species and include important spawning and nursery areas for fish species (Weisberg and Burton, 1993) and nursery and staging areas for migratory birds (i.e., places where birds temporarily stay, feed, and rest during their migrations). These habitat types are described briefly below.

The open water zone includes all areas with water deeper than 2 m (6.6 ft) at low tide. Herring (*Clupeidae*) and anchovies (*Engraulidae*) are common in the open waters of the transition zone (PSEG, 1999c). Use of this extensive habitat varies depending on the species considered. Some species such as the white perch *(Morone americana*) are year-round residents and have adapted to the different conditions found throughout the estuary. Others such as striped bass *(Morone saxatilis*) enter the estuary to spawn only for relatively short periods of time and then return to the ocean. However, the young of many resident and transient species spend at least some part of their early life history in the estuary. For example, striped bass hatch in the transition zone and move downstream in search of nursery habitat, whereas the planktonic life stages of weakfish *(Cynoscion regalis*) use tidal fluctuations to migrate upstream. This aquatic environment also supports a rich diversity of waterfowl and shorebirds that use adjacent terrestrial or semiterrestrial habitat for nesting and resting but rely on the productivity of the estuary for food and sustenance.

The littoral zone includes the intertidal zone as well as nearshore areas less than 2 m (6.6 ft) deep at low tide. The fish communities of littoral areas vary with salinity and substrate type. Among the most common littoral zone fish species are bay anchovy (*Anchoa mitchilli*), Atlantic menhaden (*Brevoortia tyrannus*), Atlantic croaker (*Micropogonias undulatus*), mummichog (*Fundulus heteroclitus heteroclitus*), weakfish, bluefish (*Pomatomus saltator)*, striped bass, white perch, and

Atlantic silverside *(Menidia menidia)* (PSEG, 1999c; U.S. EPA/ORD, 1998). Although less common, American shad (*Alosa sapidissima*) is also found in littoral areas of the transition zone.

The littoral zone is also important for geese, ducks, loons, herons, egrets, gulls, terns, and shorebirds such as plovers and sandpipers; in May and June the estuary's beaches and mudflats host the second largest population of migrating shorebirds in North America (PSEG, 1999c; Delaware Estuary Program, 1996). These birds are attracted to the eggs of spawning horseshoe crabs and other food resources, and feast on them on their journey north. The Pea Patch heronry, located on the upper bay, is the largest heronry in the northeastern United States (Delaware Estuary Program, 1996).

The benthic zone consists of substrate in the deeper parts of the estuary. Many important commercial and recreational fish species are found at least seasonally in the benthic zone, including weakfish, bluefish, striped bass, and white perch (PSEG, 1999c).

The tidal marsh zone includes freshwater emergent marshes of the tidal river, tidal scrub/shrub and forested wetlands along shorelines of tidal tributaries, and the coastal marshes of Delaware Bay (PSEG, 1999c). The most abundant salt marsh fish include mummichog, spot (*Leiostomus xanthurus*), white perch, Atlantic menhaden, bay anchovy, and Atlantic silverside.

B1-2.3 Major Environmental Stressors

In the 1940's, the lower Delaware was essentially an open sewer, with some reaches so polluted that the water was devoid of the oxygen needed to support aquatic life (DRBC, 1998). Beginning in the 1960's, comprehensive efforts were undertaken to address the severe pollution problems, and today the river supports healthy, year-round fish populations of many highly valued species such as striped bass, herring, and shad.

The Delaware Estuary still faces significant environmental challenges despite the recent improvements in water quality. The region still experiences habitat and water quality degradation due to industrial and municipal effluent discharges, untreated storm sewer overflow, nutrient enrichment, agricultural runoff, habitat degradation, and land use changes. As a result, sections of the estuary contain contaminated sediments, toxic contaminants in surface water, and suboptimal levels of dissolved oxygen resulting from high nutrient levels. Fish consumption advisories have been issued for several fish species because of high levels of PCBs and chlorinated pesticides in their tissue. Physical habitat alterations in selected parts of the bay have resulted in losses of hundreds of thousands of adult horseshoe crabs. Even though numerous fish populations increased over the last two decades, other species, e.g., the Atlantic sturgeon, are experiencing inadequate population growth or are still declining (Delaware Estuary Program, 1996; DRBC, 1998; Santoro, 1998).

While these stressors will not be directly affected by the § 316(b) regulation, they do affect the health of the ecosystem and influence the abundance and variety of aquatic organisms present. A solid understanding of factors currently limiting the waterbody's health is important because the ecosystem surrounding a CWIS is one of the primary determinants of a facility's potential for adverse environmental impact. In addition, some of the facilities that operate CWIS also contribute to these other stressors, as discussed below.

a. Habitat destruction, degradation, or modification

It has been estimated that between the mid-1950's and early 1980's, Delaware, New Jersey, and Pennsylvania lost over 50 percent of their wetlands (Jenkins and Gelvin-Innvaer, 1995). Others have put the loss at closer to 25 percent (Delaware Estuary Program, 1996). Irrespective of the precise extent of wetland losses, nontidal freshwater and forested wetlands have been more affected than the tidal marshes. Existing federal and state regulations limit further wetland loss from human encroachment. However, in the past, tidal wetlands have been lost, degraded, or modified by spoil disposal practices, residential developments, parallel-grid ditching for mosquito control programs, impoundments, diking to support salt-hay farming, and agricultural uses. The non-native common reed (*Phragmites australis*) has overrun large areas of tidal marsh habitat and outcompeted the diverse native plant species. This has reduced the overall biological value of this type of habitat by eliminating feeding and nesting areas for waterfowl and wading birds.

Dredging activities to support shipping in the estuary over the last 100 years have had both positive and negative consequences for estuarine habitats (Delaware Estuary Program, 1996). In many cases, dredge spoils were simply deposited on adjacent marshlands, which were subsequently lost to industrial development. Other dredged material was deposited on dredge-disposal islands within the estuary. Trees grew on the dredge-disposal islands and provided habitat for a large number of nesting colonies of wading birds (Jenkins and Gelvin-Innvaer, 1995).

The dredged ship channel increased the tidal range in the upper estuary because the dense marine water can now push further upstream. However, other factors involved in this process include general sea level rise and a decrease in the river debit due to upstream removal of freshwater for drinking water. The intensified ship traffic within the estuary has also resulted in increased shoreline erosion due to ship wakes. A combination of these two factors has been blamed for a decrease in intertidal vegetation in the upper and transitional estuary (Delaware Estuary Program, 1996).

Rising sea levels over the next century in response to global warming are also seen as a significant threat to the well-being of the tidal wetlands around the estuary (Delaware Estuary Program, 1996). Any further loss can directly affect anadromous and indigenous fish species by eliminating nursery habitat or resident and migratory bird species by removing nesting, feeding, or staging areas.

b. Introduction of non-native species

Under the right environmental conditions, non-native species can upset entire ecosystems. For example, the introduction of the sea lamprey into the Great Lakes in the 20th century was in part responsible for the decline of big game fish. The more recent introduction of zebra mussels has had dramatic negative effects on the Great Lakes food chain. Such "exotic" species can cause tremendous harm by displacing native species or radically changing native habitats.

A number of non-native species such as largemouth and smallmouth bass, grass carp (*Ctenopharyngodon idella*), hydrilla (*Hydrilla verticillata*, a prolific aquatic weed), and purple loosestrife (*Lythrum salicaria*) have become established in and around the estuary. The zebra mussel, though not yet present in the Delaware River system, could be introduced via ship ballast water. Nutria, a non-native and destructive rodent introduced elsewhere in the country for its fur, is present along Chesapeake Bay and has the potential of reaching the Delaware. Proposals have also been made to introduce non-native species such as the Japanese oyster and Pacific salmon for commercial and recreational reasons (Delaware Estuary Program, 1996).

The common reed *(Phragmites australis)* exemplifies how a non-native species can have far-ranging effects on an ecosystem. *Phragmites* is a highly competitive plant that has overpowered and replaced native marsh plants in thousands of acres of emergent tidal wetlands along the Delaware Estuary. This has led to a significant drop in available food resources, habitat diversity, and open water space and affects a number of species, including ducks, which are excluded from these infested areas. An aggressive eradication program has been proposed to reduce the amount of *Phragmites* cover in wetlands by 40 percent over the next decade and allow natural revegetation by pre-*Phragmites* marsh plants[4] (Delaware Estuary Program, 1996). In addition, recommendations have been made for developing and implementing an estuary-wide program to assess the potential effects of intentional introductions of non-native species and prevent unintentional future introductions (Delaware Estuary Program, 1996).

c. Overfishing

The long-term decline of the Delaware fisheries in the 20th century was due primarily to low dissolved oxygen (DO) concentrations and high levels of pollution. Since the early 1980's, when these two problems were brought under control, many of the original fish stocks have experienced a comeback. The commercial and recreational fisheries resources within the Delaware Estuary, however, are all strictly regulated to avoid overfishing and protect the stocks. A number of species-specific fishery management plans have also been developed and implemented throughout the estuary and across jurisdictional lines to provide coordinated protection. For example:

- The recovery of the striped bass population in the estuary in the 1970's and early 1980's may have been impeded by overfishing due to lack of regulatory controls at the time. In fact, Delaware completely closed down the fishery between 1985 and 1989 to help the stock recover. New Jersey and Pennsylvania ban commercial fishing for this species. Delaware allows a small gill net fishery. Recreational fishing is permitted in the three states, but the daily bag limit is one legal-size fish. In addition, the spawning grounds are closed to striped bass fishing during April and May (Miller, R.W. 1995).

- The Atlantic menhaden is a strictly regulated species and has become an important recreational fishery within the estuary and nontidal river. For example, purse seining for this species is prohibited in most of the bay. In 1992, a new fishery management plan was adopted by the Atlantic Menhaden Board of the Atlantic States Marine Fishery

[4] *Phragmites* eradication measures often consist of a combination of herbicide and burn treatments, which in themselves may have negative environmental side effects.

Commission. This plan relies on biological “triggers” to tell the fisheries managers when to close the fishery to protect the species (Hall, 1995).

- The American shad fishery in the estuary is being managed under a 1982 fishery management plan. The plan sets forth four specific goals: (1) achieving a predetermined annual spawning population size, (2) supporting a recreational sport fishery in the nontidal river, (3) maintaining a basic commercial harvesting rate, and (4) restoring shad spawning areas that have been closed to migration because of dams (Miller, J.P., 1995).

d. Pollution

The Delaware Estuary is an ecosystem on the rebound from severe water quality impairment (Delaware Estuary Program, 1996). The upper estuary (i.e., the tidal, freshwater portion of the tidal zone) was once considered one of the most polluted rivers in the United States. From the early 1990’s until the 1970’s, high biological oxygen demand (BOD) rendered the region around Philadelphia/Camden almost *anoxic* during several months of the year. The lack of DO served as a “pollution block,” preventing the spawning migration of anadromous fish upstream into the nontidal, freshwater reaches of the Delaware River. As a result, several species, including striped bass and American shad, showed severe population-related declines. A combination of industrial effluent controls and improvements in municipal sewage treatment, completed in the late 1980’s, has since reversed this problem and has resulted in one of the most successful estuarine water quality improvements in the world (Santoro, 1998). Indeed, the numbers of juvenile striped bass and American shad have increased more than a thousandfold since the early 1980’s (Weisberg et al., 1996).

The kind of separation between freshwater- and salt water layers observed in other bays and estuaries, which can lead to severe DO depletions during the summer months (notably in the Chesapeake Bay), does not typically occur in the Delaware Estuary. This is because there is little stratification between fresh and salt water due to the unique shape of the estuary, its relatively shallow depth, and the strong tidal currents within it, all of which promote mixing. Consequently, even though the Delaware River is highly enriched with nutrients, the combination of high turbidity and hydrologic mixing limits the amount of DO depletion during the summer months. Occasional DO deficits still reflect inputs of high BOD compounds from the major urban areas surrounding the upper estuary.

A number of facilities of concern to § 316(b) add to the estuary’s pollution load through effluent releases. These include pulp and paper plants, refineries, chemical facilities, and primary metal facilities. In addition, electric utilities can release chemicals to the receiving water in the form of antifouling agents or anticorrosives that are added to cooling water to protect pipes and other structures.

Ongoing sources of pollution in the estuary include contaminated sediments, point and nonpoint sources of aquatic toxicants, and thermal discharges.

❖ *Contaminated sediments*

Sediments act as long-term reservoirs for contaminants, which can be released back into the water column or passed up into the food chain. Several chemicals present in Delaware Estuary sediments (in particular mercury, DDT and its metabolites, other pesticides, and PCBs) can bioaccumulate and are difficult to eliminate once they are ingested by aquatic organisms. As a result, the concentrations of these compounds increase as they move up the food chain. This becomes a long-term problem for predators, in particular piscivores (predators that consume fish), because high levels of these chemicals are present in their prey. Fish consumption advisories are posted throughout the estuary and a section of the nontidal river because of unacceptable levels of PCBs in several recreational fish species (DRBC, 1998; Santoro, 1998). In addition, reproductive success in fish-eating raptors is believed to be impaired by the presence of these chemicals in their food source, because they lead to egg shell thinning (Clark, 1995; Niles, 1995).

❖ *Aquatic toxicants from point and nonpoint sources*

Although water quality has improved markedly since new water quality regulations were implemented in the 1970’s, the presence of bioaccumulative compounds (DDE, chlordane, PCBs) within the aquatic food chain is still a concern (DRBC, 1998). Fish and shellfish in the Delaware Estuary contain some of the nation’s highest levels of chemical contaminants (U.S. EPA/ORD, 1998). The presence of these chemicals has resulted in fish consumption advisories for channel catfish and white perch, to limit the potential effects on human health (DRBC, 1998). A 1990 study to assess the chronic toxicity of ambient waters indicated significant growth reductions of fathead minnow larvae in 8 of 12 surface water samples collected throughout the upper estuary. These results suggested that large stretches of the upper estuary may be chronically toxic to sensitive life stages of aquatic organisms under specific hydrological and effluent loading conditions. The most toxic water samples were collected in areas impacted by industrial and municipal effluent outfalls. It is unclear from the available information if more recent bioassay data exist or if additional studies have been conducted to clarify the effects of tides, currents, seasons, and effluent loadings on the observed toxicity (DRBC, 1998; Santoro, 1998).

❖ ***Thermal discharges***

In the Delaware River Basin, numerous steam-electric and industrial facilities release heated water to the estuary, which can increase water temperatures above levels that are tolerated by aquatic life. Thermal discharge is a byproduct of the cooling cycle of power plants and other industrial facilities. Production processes that generate heat generally use cool water to remove excess heat from the production process and transfer it to the cooling water. The heated water can either be cooled and reused within the facility (as in closed-cycle or recirculating systems), or it can be directly released to the environment (as in once-through systems). The environmental impacts of thermal discharges are site specific and depend on factors such as the size and/or flow of the receiving water, temperature differences between the discharge and the receiving water, the time of year, and the biological characteristics of the affected aquatic community.

B1-3 Water Withdrawals and Uses

Nearly 10 percent of Americans rely on the waters of the Delaware River Basin for drinking and industrial use (DRBC, 1998). The waters of the Delaware River and its tributaries provide drinking water, irrigation water, and water for industrial manufacturing processes, electricity generation, mining, and livestock. Water use can be classified as either "instream" or "offstream." As its name implies, instream use does not require removal of water from its source and therefore does not involve intake structures. The primary instream use of water is for hydroelectric power generation. Offstream water use, on the other hand, does involve water withdrawals through intake structures and is therefore of interest to the § 316(b) regulation. This subsection discusses water withdrawals and uses in the Delaware River Basin.

Total water withdrawals from the Delaware River Basin averaged 6,801 MGD in 1995. Of this total, 91 percent were surface water withdrawals from rivers, streams, lakes, and estuaries and 9 percent came from groundwater. The term "water withdrawal" refers to water removed from the ground or diverted from a surface water source (USGS, 1995).

Large withdrawals of water can lead to a number of water management and ecological problems. Of greatest concern to this regulation is the I&E of aquatic organisms that inhabit the waterbodies from which facilities withdraw water through intake structures. In addition, overwithdrawal and overconsumption of water can increase salt water intrusion into aquifers that supply drinking water. An excessive level of salt in drinking water presents a known risk to human health. To date, there is no evidence that withdrawals from the Delaware River and its tributaries pose salinity or turbidity problems or that withdrawals are increasing enough to make such problems likely in the future. Because of reduced power generation cooling and public supply water management programs, water withdrawals for the Delaware Basin have actually decreased since in the late 1980's (Delaware Estuary Program, 1996).

B1-3.1 Cooling Water Use

In 1995, steam electric power generation[5] accounted for the single largest intake of water from the Delaware River Basin, at 72 percent of all surface water withdrawals. While this number has decreased in recent years because more power plants have moved to closed-cycle cooling systems rather than once-through systems (DRBC, 1996), the total withdrawal of this group is still substantial.

Table B1-2 summarizes cooling water intake flows of all utility-owned power plants, nonutilities, and manufacturing facilities in the transition zone of the Delaware River Basin, including facilities subject to § 316(b) regulation and those that are not yet affected. Both design and average annual intake flow rates are presented.

[5] Steam power generation is defined by the United States Geological Survey (USGS) as thermoelectric generation, which includes the generation of electric power with fossil fuel, nuclear, or geothermal energy.

Table B1-2: Characteristics of § 316(b) Facilities Operating CWIS in the Transitional Zone of the Delaware Estuary, 1999

EIA Plant Code	Plant Name	CWIS Information				HUC Watershed Code
		EIA CWIS Code	CWIS Type[a]	Design Intake Flow Rate (ft^3/sec)	Average Annual Intake Flow Rate (ft^3/sec)	
Electric Power Plants						
593	Edge Moor	3	OF & OS	100	60	2040204
		4	OF & OS	148	107	
		5	OF & OS	581	303	
2384	Deepwater	1	OS	101	83	2040204
		4	OS	102	60	
		6	OS	97	76	
2410	Salem	SA1	OS	1,678	1,359	2040204
		SA2	OS	1,678	1,284	
6118	Hope Creek	HC1	RN	95	52	2040204
7153	Hay Road[b,c]	n/a	n/a	n/a	1.6	2040204
10043	Logan Generating Co.[c,d]	n/a	n/a	n/a	1.4	2040204
10566	Chambers Cogen LP[b,c,e]	n/a	n/a	n/a	37	2040204
			Total Electric Power Plant Intake	**4,580**	**3,424**	
Manufacturing Facilities[b]						
Delaware City Refinery[c]		n/a			339	2040204
DuPont[c]		n/a			7	2040204
General Chemical Corporation[c]		n/a			24	2040204
SPI Polyols[c,d]		n/a	n/a	n/a	5	2040204
Citisteel[c,d]		n/a	n/a	n/a	0	2040204
Sun Refining[c,d]		n/a	n/a	n/a	6	2040204
				Total Manufacturing Facility Intake	**382**	

[a] U.S. Department of Energy, 2001a. Form EIA-767 codes for relevant CWIS types: OF - once through, freshwater; OS - once through, saline water; RN - recirculating with natural draft cooling tower.
[b] Based on EPA's Section 316(b) Industry Survey, these facilities are not in scope of the proposed section 316(b) Phase II rule: Hay Road because it does not hold an NPDES permit; Chambers Cogen LP because it does not directly withdraw cooling water from a surface water source. Manufacturing facilities are subject to Phase III of the section 316(b) regulations.
[c] Intake flow information from the Delaware River Basin Commission (DRBC, 1996).
[d] These facilities are not analyzed for this proposed rule because they were not part of the second phase of EPA's industry survey effort. However, all facilities withdraw from the Delaware River and are therefore presented in this table.
[e] Listed in DRBC (1996) as an industrial facility ("DuPont Chambers").
Sources: CWIS information: U.S. Department of Energy, 2001a (except where noted); HUC codes: Reach File 1, U.S. EPA, 1982b.

B1-4 SOCIOECONOMIC CHARACTERISTICS

The Delaware River Basin is a highly valuable economic resource, providing the physical environment and biological resources for numerous commercial and recreational activities. It also supplies water for many different purposes, among others drinking water for 20 million people (Delaware Estuary Program, 1996). The region supports over 6.5 million people (Delaware Estuary Program, 1996; Santoro, 1998), and includes the city of Philadelphia, the fifth largest metropolitan area in the country. Between 1970 and 1990, 10 of the 22 counties in the region experienced population growth of more than 20 percent, resulting in rapid suburban development and more than 300,000 new housing units. The regional population is expected to grow by an additional 14 percent by 2020. The projected growth, however, will not be evenly distributed across the region. Indeed, the historical urban centers will continue to experience a net population loss, whereas the surrounding regions will show a net gain. Philadelphia, for example, is projected to lose 76,000 people (5 percent of its current population) by 2020 (Delaware Estuary Program, 1996; Santoro, 1998).

Not unexpectedly, the suburban sprawl associated with these demographic changes has profoundly affected land use patterns: large tracts of forest and agricultural lands have been converted into roads or housing and commercial developments. This activity consumes land, reduces terrestrial habitats, and directly affects the quality of the water in the estuary (Delaware Estuary Program, 1996). As an example, the Delaware Valley Regional Planning Commission (DVRPC) analyzed the 1990 land use patterns in its nine-county region and extrapolated these results to project future land use consumption through 2020. In 1990, the DVRPC estimated that 37 percent of the land area was developed. By 2020, the DVRPC projects that 51 percent of the land area will be developed, leaving less than half as agricultural, wooded, or vacant land or water (Delaware Estuary Program, 1996).

This subsection highlights the most important economic uses of the Delaware River Basin. Many of these uses may benefit from § 316(b) regulations and are therefore of particular interest to this study.

B1-4.1 Major Industrial Activities

a. Shipping

Commercial and recreational shipping activities take place throughout the Delaware Estuary, providing substantial support to the regional economy. The Port of Philadelphia, for example, generated $335 million in business revenue in 1997 (DRBC, 1998). The Philadelphia Regional Port Authority estimated that state and local taxes from port activities that year totaled $13 million and supported 3,622 jobs (DRBC, 1998).

Dredging operations have been ongoing in the Delaware Estuary for more than 100 years to support shipping and accommodate ever larger ships. Currently, the ship channel is 12-14 m (40 to 45 ft) deep and is maintained by annual dredging that removes and disposes of over 6 million cubic yards of sediments. In 1996, the cost was $15 to $18 million (Delaware Estuary Program, 1996).

b. Heavy industry

The Delaware River Basin has one of the largest concentrations of industrial facilities, oil refineries, and petrochemical plants in the world (DRBC, 1998). Discharges from 162 industries and municipalities and approximately 300 combined sewer overflows go into the estuary alone.

- The combined ports of Philadelphia, Camden, Gloucester City, Salem, and Wilmington receive over 70 percent of the oil, over 1 billion barrels, reaching the east coast of the United States every year. The port complex is the world’s largest freshwater port and ranks second in the nation in total waterborne commerce, generating an income of over $3 billion and providing 180,000 jobs (Delaware Estuary Program, 1996).

- The Delaware Estuary supports the second largest refining-petrochemical center in the United States (Delaware Estuary Program, 1996).

B1-4.2 Commercial Fisheries

The Delaware Estuary is home to over 200 species of resident and migratory fish. Many of these species are an invaluable resource for both commercial and recreational fishing.

- At least 31 fish species are commercially harvested in the Delaware Estuary. The value of the estuary’s commercial fin fishery was about $1.4 million in 1990 (Delaware Estuary Program, 1996).

- The first recorded oyster landings in the Delaware Bay, in 1880, totaled an estimated 2.4 million harvested oyster bushels. This number decreased to about 1 to 2 million bushels until the mid-1950’s. Over the past 40 years, the oyster industry was depressed because of two diseases, MSX and Dermo, which ultimately resulted in the closure of the natural oyster beds in the Delaware Bay. When these beds reopened in 1996, fishermen harvested an estimated 75,000 bushels with a dockside value of approximately $1.6 million (Santoro, 1998).

- Shad has been an important fishery in the Delaware River since colonial times (Delaware Estuary Program, 2001). Between 1896 and 1901, the catch of shad in the Delaware River exceeded that of any other river system on the Atlantic Coast and accounted for up to 30 percent of the entire coastal catch. On average, fishermen landed 5,445 to 6,350 metric tons (12 to 14 million pounds) annually. Shad landings began to decline rapidly in the early 1900s, mainly due to pollution and overfishing. Although improved water quality and development of a fishery management plan led to some recovery after 1975, shad remain well below pre-1900 levels. High numbers of shad returned from the ocean to spawn in freshwater portions of the Delaware River in 1998 and again in 2000, but 1999 records show a very low number of returns, raising concerns about the extent to which the shad population has actually recovered. A recent study placed the current annual value of the shad fishery at $3.2 million (DRBC, 1998).

B1-4.3 Recreational Activities

a. Recreational fishing

The Delaware River Basin provides ample opportunity for recreational fishing ranging from marine fishing to freshwater and flyfishing. To characterize recreational fishing in the Delaware River Estuary, EPA relied mainly on the Marine Recreational Fisheries Statistics Survey (MRFSS) (NMFS, 2001b).

The MRFSS is a comprehensive coast-wide survey of marine recreational anglers operated by the National Marine Fishery Service (NMFS). The MRFSS is a long-term monitoring program that provides estimates of effort, participation, and finfish catch by recreational anglers. The MRFSS survey consists of two independent, but complementary, surveys: an intercept survey of anglers at fishing access sites and a random digit-dial telephone survey of households.

The basic intercept survey collects information about anglers' home ZIP code, the length of their fishing trip, the species they targeted on that trip, and the number of times anglers have fished in the past two and 12 months. Trained interviewers record the species and numbers of fish caught that are available for inspection and then weigh and measure the fish.

NMFS used the random telephone survey to estimate recreational fishing effort (i.e., trips) on a two-month basis (as opposed to annual participation) for coastal households. NMFS adjusted effort estimates for coastal households by the ratio of intercept data of coastal to non-coastal and out-of-state residents to calculate total effort. The survey asked households with individuals who had fished within two months of the phone call about the mode of fishing, the gear used, and the type of waterbody where the trip took place for every trip taken within that period. The telephone survey also collected data on the socioeconomic characteristics of recreational anglers.

The MRFSS found that, on average, participants spend approximately 28 days fishing at Delaware Bay and Atlantic coastal sites of Delaware and New Jersey each year. The Delaware Bay fishermen tend to travel relatively short distances, on average 40 miles for single-day trips and 107 miles for multiple-day trips. Fishermen taking single- and multiple-day trips spend an average of $62.43 and $100.24, respectively, in pursuit of their target species.[6]

From 1994 to 1998, recreational anglers in Delaware and New Jersey caught an annual average of:

- 18.03 metric tons (395,744 pounds) of striped bass;
- 1,265.63 metric tons (2,790,234 pounds) of weakfish;
- 2,527.29 metric tons (5,571,710 pounds) of flounder;
- 443.07 metric tons (976,795 pounds) of bluefish; and
- 1,385.37 metric tons (3,054,216 pounds) of bottom fish (including Atlantic croaker, tautog, spot, and white perch).

Table B1-3 shows the results of the MRFSS analysis of fishing participation at the lower Delaware Bay Estuary and adjacent coastal sites in Delaware and New Jersey. The table presents the five-year average of total fishing days by state and by fishing mode (1994 through 1998); this total number of fishing days includes both single- and multiple-day trips.

Table B1-3 shows that anglers spent an estimated 5.4 million days fishing at the lower Delaware Bay Estuary and adjacent Atlantic coastal sites. The NMFS data show that recreational fishing in the estuary and adjacent coastal sites is largely limited to residents living close to the case study area, such as residents of Delaware, New Jersey, Pennsylvania, and Maryland.

In addition to species reported by the NMFS, a 1986 creel census found that anglers made 65,690 trips and spent 299,597 hours fishing for shad in the Delaware River. This survey also estimated the economic value of recreational shad fishing in the Delaware River in 1986 to be $3.2 million (Miller, J.P., 1995).[7]

[6] Includes travel and boat expenditures for single-day trips and travel, lodging, and boat expenditures for multiple-day trips.

[7] This number reflects a $50/day replacement value.

Table B1-3: Recreational Fishing Participation in the Lower Delaware Bay Estuary and Atlantic Coastal Sites in Delaware and New Jersey

Visited State	Fishing Mode	Total Number of Fishing Days at the Delaware and New Jersey NMFS Sites
DE	Private or Rental Boat	390,578
DE	Shore	367,402
DE	Charter Boat	43,339
NJ	Private or Rental Boat	2,596,380
NJ	Shore	1,596,531
NJ	Charter Boat	403,523
Total		**5,397,753**

Source: NMFS, 2001b.

b. Bird watching

Hundreds of thousands of migrating birds use the estuary's high biological productivity on their way to and from their overwintering and breeding grounds. In fact, the estuary is one of the most important feeding sites for shore birds in North America, with an estimated 425,000 to 1 million shorebirds arriving during their spring migrations. The arrival of migratory birds, together with numerous year-round avian residents, has promoted a burgeoning bird watching industry. In 1988, an estimated $5.5 million was spent by more than 90,000 bird watchers in the Cape May area alone. Much of this activity occurred in the "off-season" and provided a significant economic boost to the region (Delaware Estuary Program, 1996).

> Bird Watching in the Delaware Bay
>
> "The marshy convergence of water and land along the Delaware Bay shoreline, long resistant to human encroachment, encompasses some of the Atlantic coast's finest birding sites. Waterbirds of one sort or another, from loons to terns, are present throughout the year. This is one of the country's best places to find Curlew Sandpiper, a rare wanderer from breeding grounds in Siberia, and Ruff, another sandpiper that nests in Scandinavia and northern Asia."
>
> *White*, 1999

Figure B1-3 shows the most important bird watching areas along the Delaware River Basin. The following text highlights some of these areas.

❖ *Bombay Hook National Wildlife Refuge*

The Bombay Hook National Wildlife Refuge extends for approximately 6,070 hectares (15,000 acres) along the Atlantic Coastal Plain on the western shore of Delaware. The refuge provides a wide diversity of habitat types (including artificial bays and marshes, upland woods, swamps, brushy thickets, grassy fields, and croplands) and attracts numerous species of birds. Bombay Hook was originally established in 1937 as a link in the chain of waterfowl refuges that extends from Canada to the Gulf of Mexico. It is mainly a refuge for migrating and wintering ducks and geese but also hosts numerous other species of migratory birds (Great Outdoor Recreation Pages, 1999). The importance of Bombay Hook as a recreational area has increased greatly in the past 25 years, mainly because of the loss of extensive surrounding marshland to urban and industrial development. Approximately 128,500 visitors explored the refuge in 1998 (Personal Communication, Marion Pohlman, Bombay Hook National Wildlife Refuge, September 21, 1999).

Wildlife can be seen year round at Bombay Hook. In October and November, waterfowl populations are at their peaks, when over 100,000 ducks and geese use the refuge. March is the second peak for waterfowl that travel through on their return to northern breeding grounds. April brings early shorebird migrants. Shorebirds are at their highest concentrations during May and June, mainly because of the arrival of horseshoe crabs laying eggs along the bay shore and mud flats. These eggs provide the shorebirds with needed energy to complete their northward migration. Wading birds such as herons, egrets, and glossy ibis reach their peak numbers during the summer months (Great Outdoor Recreation Pages, 1999). Bombay Hook also hosts the greatest concentration of snow geese in North America and has a long history of nesting eagles. The refuge includes a 12-mile auto tour loop and five trails from which visitors can view the wildlife.

Figure B1-3: Bird Watching Areas of the Delaware River Basin

Source: Delorme, 1993, 1999; USGS, 2000.

❖ *Cape May Peninsula*

The Cape May peninsula is world renowned for its importance to migratory birds. Cape May is situated at the end of a peninsula separating Delaware Bay from the Atlantic Ocean. The peninsula acts as a funnel for songbirds, shorebirds, waterfowl, butterflies, and hawks migrating along the Atlantic Flyway. Cape May provides critical staging areas that provide important resting and feeding opportunities for migrating birds. The Cape May natural and recreational areas include:

- **Cape May Point State Park:** A large portion of the park is a designated Natural Area and has more than 3 miles of trails and boardwalks for nature study and hiking. The "Hawk Watch" observation platform provides an excellent view of one of the nation's most extraordinary autumn hawk migrations. Beginning in September and extending through December, tens of thousands of raptors, including bald eagles, peregrine falcons, ospreys, goshawks, Cooper's hawks, and various species of owl pass the platform (Pettigrew, 1998). From July 1, 1998, through June 30, 1999, over 800,000 people visited the park (Personal Communication, Cape May Point State Park, September 21, 1999).

- **Higbee Beach Wildlife Management Area:** Higbee Beach is a 2.4 km (1.5 mile) stretch of beach containing the last remnant of coastal dune forest on the bay shore, where visitors can admire hundreds of species of migrating songbirds and hawks. Higbee Beach is managed specifically to provide habitat for migratory wildlife. In addition to millions of songbirds, nearly 50,000 raptors migrate over the peninsula every year, and many stop here to rest and feed (Pettigrew, 1998).

- **William D. and Jane C. Blair Cape May Migratory Bird Refuge:** This area is recognized as one of the East Coast's premier birding spots. Thousands of raptors, shorebirds, songbirds, and waterfowl pass through the refuge on their way south. The refuge provides a haven for two state-listed endangered species: the least tern and the piping plover. New Jersey's beaches comprise a significant portion of the entire breeding population's nesting habitat.

❖ *Recreational viewing reported in the Survey of National Demand for Water Based Recreation*

The Agency used EPA's 1994 *Survey of National Demand for Water-Based Recreation* (National Demand Survey, NDS) to characterize recreational wildlife viewing at the Delaware River Basin. EPA cooperated with the National Forest Service and several other federal agencies and interested groups to collect data on the outdoor recreation activities of Americans. EPA's goal was to quantify the number of people who participate in water-based recreation and their total number of recreation trips. In addition, the survey was intended to explain how water quality conditions and other characteristics of water resources affect these numbers. Table B1-4 shows the results of the survey for the Delaware River Basin. The table presents two key results (shaded columns): (1) the extrapolated national number of people who visited the Delaware River Basin during 1994, and (2) the extrapolated national number of wildlife viewing trips to the Basin.[8]

To determine the total number of wildlife viewing participants from each state, EPA used the percentage of survey respondents from each state that reported having visited the basin and the total number of state residents 18 and older.[9] In addition, the survey collected information on the number of times the respondents visited the site of their last viewing trip. EPA used this number to derive an average number of trips per visitor to the Delaware River Basin and the total number of wildlife viewing trips by state.

Table B1-4 uses a 1994 recreation participation survey to estimate wildlife viewing in 2000. Approximately 1.4 million people used the Delaware River Basin for wildlife viewing.[10] These visitors accounted for about 5.1 million recreational trips to the area. Residents of Pennsylvania, New Jersey, and Delaware were the most frequent visitors.

---

[8] Notably, the NDS collected information only on the *last* site visited. These numbers do not reflect people whose last visit was to a different area but who may have also visited the Delaware River Basin on a previous trip during the year. For the remainder of the NDS results discussion, the reported numbers of respondents and their trips refer only to respondents whose last trip was to the Delaware River Basin.

[9] The survey collected information only on respondents 18 or older.

[10] Note that given the small sample size, estimates of the total number of trips to the Delaware River Basing have a larger than desirable degree of uncertainty.

Table B1-4: National Number of Participants in Wildlife Viewing in the Delaware River Basin (DRB) in 2000								
Home State	**2000 State Population (18 & over)**	**Number of Survey Respondents**	**Number of Respondents with Last Recreational Viewing Trip to the DRB**		**Extrapolated Number of Participants in Recreational Viewing in the DRB**	**Number of Recreational Viewing Trips to the DRB by Last Trip Participants**	**Average Number of Recreational Viewing Trips per Respondent**	**Extrapolated Number of Recreational Viewing Trips in the DRB**
			Total	**% of Survey Respondents**				
CT	2,563,877	159	1	0.6%	N/A	1	1.0	N/A
DC	457,067	35	2	5.7%	N/A	3	1.5	N/A
DE	589,013	51	14	27.5%	161,690	112	8.0	1,293,519
FL	12,336,038	662	2	0.3%	N/A	2	1.0	N/A
IN	4,506,089	300	1	0.3%	N/A	2	2.0	N/A
MD	3,940,314	257	12	4.7%	183,984	21	1.8	321,971
NC	6,085,266	407	1	0.2%	N/A	1	1.0	N/A
NJ	6,326,792	346	15	4.3%	274,283	75	5.0	1,371,414
NY	14,286,350	774	4	0.5%	73,831	5	1.3	92,289
OH	8,464,801	650	1	0.2%	N/A	1	1.0	N/A
PA	9,358,833	742	52	7.0%	655,875	151	2.9	1,904,560
VA	5,340,253	389	5	1.3%	68,641	9	1.8	123,553
WI	3,994,919	299	1	0.3%	N/A	1	1.0	N/A
Total		**5,071**	**111**		**1,418,303**	**384**	**3**	**5,107,307**

Source: Survey of National Demand for Water-Based Recreation (U.S. EPA 1994b)
N/A: EPA did not extrapolate sample-based results due to insufficient number of observations.